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Title: Gender difference in suicide in Taiwan over a century: a time trend analysis in 1905-1940 and 1959-2012

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Abstract

Background: Suicide rates are higher in males than females in most countries, although the gender ratios vary markedly worldwide. We investigated long-term trends in suicide rates and the male-to-female ratios in relation to age, method, and economic factors in Taiwan during the Japanese colonial (1905-1940) and post-war (1959-2012) periods.

Methods: Suicide data were from the Statistical Reports of Taiwan Governor's Office (1905-1940), Vital Statistics (1959-1970) and cause-of-death mortality data files (1971-2012). Annual age-standardised and age/method-specific suicide rates by gender and the gender ratios were calculated and examined graphically. The associations between trends in economic indicators, suicide, and suicide gender ratio were investigated using Prais-Winsten regression.

Results: The male-to-female suicide rate ratio increased from below one in the 1900s to around two by 2000; the reversal was mainly due to a marked reduction in suicide rates in young females coupled with a rise in male suicide between 1905-1940. The gender ratio increased again from the 1980s onwards. Poisoning was the most common method in the 1970s-80s but its use decreased afterwards, more in females than males proportionally. The use of gassing for suicide increased markedly in the

2000s and contributed to the rises in overall suicide and the gender ratio.

Unemployment rates were more strongly associated with male suicide than female suicide in 1959-2012. Unemployment rates and GDP per capita were positively associated with suicide gender ratios.

Conclusions: Gender differences in suicide changed remarkably in Taiwan over the past century; such change may be related to cultural, socioeconomic, and method-specific factors.

Keywords

Suicide; Trend; Epidemiology; Taiwan; Time trend analysis; Gender difference

Introduction

Suicide is a major global public health concern. One striking feature of the epidemiology of suicide is that suicide rates are higher in males than females in most parts of the world,¹ with a few noticeable exceptions such as India and China.^{2, 3} However, there have been marked changes in the gender pattern of suicide in India and China in recent years. The male-to-female ratio of suicide rates increased from 0.96 to 1.34 in India between 1990 and 2016; this was largely attributable to a marked reduction in suicide rates in young females in some regions of the country.² In China, there was a similar reversal in the gender pattern of suicide occurred around 2006, mainly due to a marked reduction in female suicide rates in rural areas.³ However, factors underlying such reversals in the gender ratios of suicide are yet to be fully investigated.

Previous studies suggest that a range of factors may contribute to gender difference in suicide rates. Ecological studies of cross-country variations indicate that the gender ratios of suicide are associated with variations in indicators of socioeconomic development¹ and gender inequality.^{4, 5} Previous investigations into long-term suicide trends suggest that adverse macroeconomic conditions, such as rising unemployment, appear to have a stronger influence on male than female

suicide rates.⁶ An analysis of suicide from England and Wales (1861-2007) indicated that changes in the acceptability and lethality of commonly used suicide methods (e.g. different methods of gas poisoning – domestic gas vs. car exhaust gas) may contribute to large variations in gender ratios over time.⁷ However, previous studies of long-term trends in gender difference in suicide have mostly been carried out in Western countries where suicide rates have been consistently higher in males and females.^{7, 8} Few studies have investigated this phenomenon in non-Western settings; these studies tend to include a relatively short timespan^{2, 3} or only examine gender-specific suicide rates without further investigating trend in gender ratio or factors related to the change in gender ratio.⁹

Over the past one hundred years Taiwan experienced substantial changes in its social, economic, political, and cultural circumstances. It was ruled by two administrations, the Japanese colonial government (1895-1945) and the Taiwan government (1945-present), was transformed from an agrarian society to a highly-industrialised country, and experienced marked changes in women's socioeconomic position; all these provide an excellent opportunity to study the evolution of gender difference in long-term suicide trends. The aims of this study were to examine i) trends in gender-specific and gender-age/method-specific suicide

rates and the male-to-female ratio; and ii) the association of economic indicators with gender-specific suicide rates and the gender ratios in Taiwan in 1905-1940 and 1959-2012.

Methods and Analysis

Data

Suicide data during the Japanese period were collected by the police through a comprehensive system established by the Japanese Colonial Government. Data for suicide by gender, age, and method were extracted from annual Statistical Reports of the Taiwan Governor's Office (1897-1942; method-specific data available for year 1906-1940 only). Population data for the Japanese period were based on seven island-wide censuses in 1905, 1915, 1920, 1925, 1930, 1935, and 1940. Interpolation was used to calculate gender-age-specific population for each year between censuses. We restricted our analyses to data in 1905-1940 when reliable population data were available from censuses.

A centralised death registration system has been in operation since the 1950s, and the law requires that only judicial personnel are authorised to certify suicide. Suicide data (1959-2012) were obtained from Vital Statistics (1959-1970) and the

computerized cause-of-death mortality files (1971-2012) provided by Taiwan's Ministry of Health and Welfare. Detailed data post 2012 were unavailable at the time of the study. Suicide methods were classified using the International Classification of Diseases (ICD) codes (Appendix 1). Since a previous study indicated that suicide rates may be underestimated by misclassification of suicide as undetermined death, accidental pesticide poisoning, or accidental suffocation in Taiwan,¹⁰ suicide rates additionally including deaths in these cause-of-death categories were also calculated for the years 1971-2012. Population data during the post-war period were obtained from the Statistical Yearbooks.¹¹

Gross Domestic Product (GDP) per capita and GDP growth data for Japanese period were from the calculations by Wu (2004).¹² GDP data during the post-war period were obtained from the Statistical Yearbooks.¹³ Data on unemployment rates and female labour force participation rates (only available for the post-war period) were extracted from the Manpower Survey Statistics¹⁴ and the website of the Ministry of Labor,¹⁵ respectively.

Statistical analysis

Age-standardized suicide rates per 100,000 were calculated using the WHO

World Standard Population.¹⁶ Annual gender-specific age-standardised and gender-age/method-specific suicide rates were calculated. Age-specific suicide rates were calculated using 10-year age bands (0-19, 20-29, 30-39, 40-49, and 50+ years) as suicide data in the Japanese period were only available for these age categories. During the post-war period, suicide trends were very similar in people aged 50-64 and 65+ years (Appendix 2). We analysed the male-to-female ratio of suicide rates by age group and suicide method. Trends in suicide rates and the gender ratios were plotted using three-year moving averages centred on the middle year of each 3-year period to smooth the annual rates/ratios.

To deal with serial autocorrelation in the time series data for suicide and economic variables, we used Prais-Winsten regression to study the associations of economic indicators including unemployment rate, GDP per capita, GDP growth, and female labour force participation rate with gender-specific suicide trends and the gender ratio of suicide rates. Adjusted regression analyses included all economic indicators for which data were available, as well as the year variable to control for time trend.

Results

During the Japanese colonial period (1905-1940), male age-standardised suicide rates showed a generally upward trend whilst females showed a relatively stable trend (Figure 1a). Male suicide rates increased to a peak in 1938; some reductions were found in 1923-26, followed by an increase in 1927, when the Shōwa Financial Crisis (a financial panic with 37 banks going bankrupt) occurred. In contrast, female suicide rates fluctuated over the period. The male-to-female ratios of suicide rates increased from below one (range 0.80-0.99) in 1905-1911 to 1.8 in 1940 (Figure 1b).

During the post-war period (1959-2012), suicide trends were generally similar in males and females (Figure 1a). Suicide rates fell from a peak in 1964 (males) and 1965 (females) to the lowest rates in 1993, despite a slight upturn in the early 1980s when the oil crisis occurred. Suicide rates subsequently increased until reaching a relative peak in 2006 (males) and 2005 (females). Overall trends were similar when possibly misclassified suicides were included from 1971. The male-to-female ratios of suicide rates remained relatively stable through the 1960s-70s and subsequently increased from the 1980s, reaching a peak of 2.32 in 2006 (Figure 1b).

Trends in age-specific suicide rates differed markedly in males and females in 1905-1940 (Figure 2). Males aged 50+ showed the largest increase in suicide, with a

two-fold rise during this period, whilst male rates in other age groups increased moderately (1.3- to 1.6-fold). By contrast, females showed divergent trends in suicide across age groups, with those aged below 40 showing a downward trend and those aged 50+ showing an upward trend. Women aged 20-29 had the highest rates until 1931; suicide rates of this group declined by half in 1911-1932 and were first time surpassed by women aged 50+ in 1932, whose rates increased 2.3-fold in 1905-1932. In 1905, the male-to-female ratio of suicide rates increased with age from 0.3, 0.5, 1.0, 2.1, to 2.2 in 0-19, 20-29, 30-39, 40-49, and 50+ year-olds respectively. The three youngest age groups showed an increase in suicide gender ratio (Figure 3), indicating that the increase in the gender ratio of suicide in the Japanese period was driven by falls in suicide rates in young females aged below 40.

In 1959-2012, males and females of all age groups showed generally similar trends (Figure 2). The highest age-specific rates of both genders were observed in those aged 50+ after 1964 and the lowest rates were consistently seen in those aged 0-19. Of note, those aged 20-29 had relatively high suicide rates compared to other age groups, except those aged 50+, before the mid-1960s but showed a marked reduction in rates afterwards. The male-to-female ratios of suicide rates increased in all age groups during the post-war period despite some brief fluctuations (Figure 3).

There were marked changes in method-specific suicide rates over time (Figure 4a and 4b). In 1905-1940, the dominant suicide method in both genders was hanging, accounting for 68-87% of male suicides and 63-85% of female suicides. Suicide rates by drowning (both genders) and poisoning (males only) increased gradually over the period. The male-to-female ratio of suicide rates was highest for 'other methods' (mainly cutting and crashing by vehicle) over the period (Figure 4c; Appendix 3 showed logged values of suicide gender ratio), whilst that for hanging showed an increase from 1.2 to 1.9 in 1920-1940 (Figure 4c).

In the 1960s, the most frequently used method was poisoning, accounting for nearly 70% of both male and female suicides. The proportion was particularly high (>80%) in the younger groups (Appendix 4). Poisoning suicide rates fluctuated in the 1970s - early 1980s and subsequently showed a marked reduction in the mid- and late 1980s, with no marked changes in suicide rates of other methods (Figure 4a and 4b). This reduction was more marked in females than in males (62% vs 52% in 1982-1992). Hanging suicide rates generally increased in 1967-2012 in both genders, surpassing poisoning suicide rates in 1995 (males) and 1999 (females). Of note, gassing as a suicide method was very rare before 2000, but its use increased dramatically in the following years to become the second most common suicide

method by 2005. Suicide rates by drowning, falling, and other methods were low before 1990 but gradually increased afterwards in both genders. The male-to-female ratio of suicide rates was highest for the 'other methods' category until the gassing method showed an exceptionally high gender ratio, when its use started to increase in the late 1990s (Figure 4c; Appendix 3). Male-to-female ratio for hanging suicide rates steadily increased over the period, whilst that for poisoning suicide rates increased mainly in the 1980s-90s (Figure 4c).

Trends in gender-specific suicide rates in relation to the four economic factors investigated are shown in Appendix 5. Suicide rates and unemployment rates appeared to show similar trends in 1959-2012 whilst there was no apparent correlation between trends in suicide and GDP per capita, GDP growth or female labour force participation rates.

Adjusted regression analyses showed no association of economic factors with gender-specific suicide rates and rate ratios in 1905-1940 (Table 1). In 1959-2012, unemployment rates were positively associated with both male and female suicide rates but the strength of association was greater in males (adjusted β [i.e. change in suicide rate per 100,000 per 1% increase in unemployment rate]=3.02, 95% confidence interval (CI) 2.41, 3.62) than in females (adjusted β =1.52, 95% CI 1.16,

1.88) (gender interaction $p < 0.001$). GDP per capita was negatively associated with female suicide rates (adjusted β [i.e. change in suicide rate per 100,000 per 1000 USD increase]=-0.21, 95% CI -0.42, 0.00). Male-to-female ratio of suicide rate was positively associated with unemployment (adjusted $\beta=0.04$, 95% CI 0.00, 0.08) and GDP per capita (adjusted $\beta=0.04$, 95% CI 0.02, 0.07). Sensitivity analyses excluding possibly misclassified suicides in the years 1971-2012 showed similar results (Appendix 6).

Discussion

Gender, age and method-specific suicide rates have changed markedly in Taiwan over the last one hundred years. The male-to-female suicide rate ratio increased from below one in the 1900s to around two in the 2000s. The reversal in the gender differential of suicide was mainly due to a marked reduction in suicide rates in young females coupled with a rise in male suicide in 1905-1940. After a period of stability in the 1960s the male-to-female ratio of suicide rates continued to increase from the 1980s onwards, when poisoning suicide rates declined more markedly in females than males in the 1980s and gassing suicide rates increased more markedly in males than females in the 2000s. Unemployment rates were more strongly associated with

suicide in males than in females in 1959-2012, whilst increases in unemployment rates and GDP per capita were associated with increases in the male-to-female ratio of suicide rates over the same period.

Strengths and limitations

The study is the first detailed investigation of long-term trends in gender difference in suicide in a non-Western country over the last century. There are several limitations. Suicide data were unavailable for the period 1941-1958. Suicide was certified differently in the Japanese and post-war periods; however, suicide statistics are considered to have been recorded comprehensively and reliably in both periods.¹⁷ Although different revisions of ICD were used for cause-of-death classification during the post-war period, a previous study showed no obvious impact on suicide trends in Taiwan.¹⁸ Sensitivity analyses excluding possibly misclassified suicides also showed similar findings.

Comparison with previous studies

In 1990-2016 the global suicide rate fell by an estimated 49.0% in females and 23.8% in males, resulting in an increase in male-to-female ratio from 1.37 to 2.17.¹

This increase is largely driven by changes in China and India, where age-standardised suicide rates decreased by 60.0% and 15.2% in 1990-2016, respectively.¹ In keeping with our findings of changes in suicide gender difference in Taiwan, the greatest falls in India's female suicide rates in 1990-2016 were amongst young females aged 10-34.² China also experienced a marked decrease in suicide rates in young females aged 10-19 and 20-29, particularly in rural areas, in 1990-2000;³ this was thought to be related to the rapid urbanization and massive rural-to-urban migration, which led to reduced access to pesticides and better employment and educational opportunities for young migrants from rural areas, and improved socioeconomic position of young females.³

Several factors may have contributed to the rising male-to-female ratios of suicide rates in Taiwan. During the Japanese period, one important contributor to the increase in gender ratio was a marked decrease in suicide in young females, whose socioeconomic position improved substantially over this period – there were i) a marked decrease in female infanticide, which led to over 15% deaths of female babies in 1870-1895 and was later banned by the Japanese government and almost completely eliminated by 1911;¹⁹ ii) substantially improved educational opportunities (e.g. the percentage of school-aged girls enrolled in elementary schools rose from 1%

to 61% in 1908-1943);²⁰ iii) the ban of foot-binding, an old Chinese custom that could result in substantial and lifelong limitation of mobility in females - 14% and 67% of Taiwanese young females aged <11 and aged 11-30 had bound feet in 1905, and the percentages dropped to 0.3% and 11% by 1915, respectively;²¹ and iv) social movement against the traditional arranged marriage, supporting for women's right to decide their marriage.²¹ The reduction of gender inequality could be a significant protective factor of suicide for females, particularly young females. A recent ecological study based on data from 174 regions/countries showed a higher male-to-female suicide rate ratio in countries with more egalitarian gender norms.⁴

By contrast, suicide rates increased markedly in older population during the Japanese period, in contrast to a marked reduction in overall mortality rates over the same period.²² Insufficient resources or support for the rapidly growing elderly population, as well as a breakdown in family structures and traditions that give respect to older people, might contribute to increased vulnerability in this group.¹⁷ In contrast, a study from England and Wales in 1950-1998 showed that elderly suicide rates decreased markedly with an increase in the elderly population size, and this was found to be associated with increases in national GDP, antidepressant prescribing and other measures of improved healthcare provision for older people.²³

The increase in the male-to-female ratio for suicide rates in Taiwan in the 1980s was due to a greater fall in female suicide rates (-46%) than in male rates (-33%); this mainly reflected gender differential in reductions of poisoning suicides (mostly pesticide-related)²⁴ (-44% vs -27%). Similarly, suicide rates by pesticide poisoning decreased markedly in China in 2006-2013, with a greater reduction in females than in males and more so in rural (63% vs 42% reductions in females and males respectively) than urban (43% vs 40%) areas.²⁵ The high poisoning suicide rates in Taiwan in the 1960s-70s appeared to be associated with the Green Revolution and rapid increase in pesticide use; a rapid increase in poisoning suicide rates was also seen in Sri Lanka over the same period.²⁶ By contrast, the recent decrease in pesticide poisoning suicide could be attributable to rapid urbanization and a fast decline in agricultural population, which both reduce the access to pesticides.²⁴ Males constitute the majority of the agricultural labour force and this may explain their smaller reduction in suicide by pesticide poisoning over time.

In the 1990s, the increase in the gender ratio was mainly due to a greater increase in suicide rates in males than females in Taiwan. During this period, there were year-on-year increases in unemployment rate and GDP per capita (Appendix 5). Previous time-series analyses from a number of countries consistently showed a

stronger association between unemployment rates and suicide rates in males than females.^{18, 27, 28} One recent meta-analysis of cohort studies showed that unemployment was associated with suicide only in males but not in females.²⁹ The gender difference could be because males are more likely to be the main earner in the family, experience greater shame or social isolation and misuse alcohol as a result of unemployment, and are less likely to seek help.^{27, 30} By contrast, in adjusted models, rises in GDP per capita were associated with falls in female but not male suicide rates during the post-war period, although the statistical evidence for the association was weak ($p=0.045$). Previous studies from Taiwan^{31, 32} and other counties^{33, 34} showed inconsistent findings about the association of GDP per capita, GDP growth and female labour force participation rates with male and female suicide rates.

Between the late 1990s and the 2000s there was a greater increase in suicide deaths by gassing in males than females, contributing to a further increase in the male-to-female ratio of suicide rates. Suicides by gassing (mostly from charcoal burning³⁵) increased rapidly in Taiwan in the early 21st century; marked increases were also found in other East Asian countries including Hong Kong, Japan and South Korea.³⁶ The emergence of charcoal-burning suicide was also found to widen the

gender differential of suicide rates in Hong Kong.³⁷ Similarly, in England and Wales the suicide gender ratio increased in the late 1960s-70s, corresponding to a rise in use of car exhaust gases for suicide, particularly in males.⁷ These suggest that the adoption of some new methods of suicide (e.g. gassing using charcoal and car exhaust gases) may be greater in males than females, and this could impact on overall gender ratio of suicide rates in these settings; however, there was no apparent gender difference in the emergence of domestic gas suicide in England and Wales³⁸ and charcoal-burning suicide in Japan.³⁹

Conclusion

Cultural, socioeconomic and suicide method-specific factors may have contributed to the increased male-to-female ratio of suicide rates in Taiwan over the past century. Changes in the popularity and accessibility of high-lethality suicide methods (e.g. pesticide poisoning and charcoal burning) may impact on method-specific and overall suicide rates as well as the gender differential of suicide. In Taiwan and globally, changes in the socioeconomic and cultural environments such as increased economic instability could contribute to a greater risk of poor mental health and suicide in males than females. Furthermore, emerging suicide methods could pose additional challenges for suicide prevention, particularly amongst males.

Future research should investigate gender difference in the impact of
aforementioned factors on suicide to inform prevention strategies targeted on
high-risk males.

What is already known on this subject?

- One striking feature of the global distribution of suicide is the gender difference – a higher male than female rate in most parts of the world, albeit with large, explained variations across countries.
- Notable exceptions include China and India, but their male-to-female ratios of suicide have recently reversed from below one to above one, whilst reasons underlying such reversals remain unclear.

What this study adds?

- Gender, age and method-specific suicide rates have changed markedly in Taiwan over the last one hundred years; during this period the male-to-female ratio of suicide rates increases from below one to around two, namely a reversal of the gender difference in suicide.
- Cultural, socioeconomic and suicide method-specific factors may have contributed to the increased male-to-female ratio of suicide rates.
- Government policies to tackle gender inequality, mitigate the effect of economic downturns, and restrict access to high-lethality suicide methods can be effective in preventing suicide.

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Figure Caption

Figure 1. Trends in (a) age-standardized suicide rates (3-year moving averages) by gender and (b) male-to-female ratios of suicide rates (3-year moving averages) in Taiwan, 1905-1940 and 1959-2012.

Figure 2. Trends in (a) male and (b) female suicide rates (3-year moving averages) by age group in Taiwan, 1905-1940 and 1959-2012

Figure 3. Age-specific male-to-female ratios of suicide rates in Taiwan (3-year moving averages), 1905-1940 and 1959-2012

Figure 4. Trends in (a) male suicide rates, (b) female suicide rates, and (c) male-to-female ratio of suicide rates of different methods in Taiwan (3-year moving averages), 1906-1940 and 1967-2012

Table

Table 1. Associations of economic factors with age-standardized suicide rates per 100,000 in males and females and the male-to-female ratios in Prais-Winsten regression in Taiwan, 1905-1940 and 1959-2012

	Adjusted for year only			Adjusted for year and all other economic factors		
	β	(95% CI)	p	β	(95% CI)	p
<i>1905-1940</i>						
Male						
GDP per capita (1000 USD)	3.46	(-7.42 , 14.33)	0.52	6.97	(-5.54 , 19.47)	0.27
GDP growth (%)	-0.03	(-0.14 , 0.07)	0.49	-0.07	(-0.18 , 0.05)	0.25
Female						
GDP per capita (1000 USD)	-1.05	(-8.00 , 5.90)	0.76	-0.97	(-8.60 , 6.66)	0.80
GDP growth (%)	0.00	(-0.07 , 0.06)	0.88	0.00	(-0.07 , 0.07)	1.00
Male-to-female ratio						
GDP per capita (1000 USD)	0.21	(-0.33 , 0.74)	0.43	0.39	(-0.22 , 0.99)	0.21
GDP growth (%)	0.00	(-0.01 , 0.00)	0.50	0.00	(-0.01 , 0.00)	0.23
<i>1959-2012</i>						
Male						
Unemployment (%)	2.93	(2.41 , 3.44)	<0.001	3.02	(2.41 , 3.62)	<0.001
GDP per capita (1000 USD)	0.94	(0.43 , 1.44)	0.001	0.08	(-0.27 , 0.43)	0.66
GDP growth (%)	-0.26	(-0.67 , 0.15)	0.21	0.14	(-0.08 , 0.36)	0.19
FLFPR (%)	-0.53	(-1.26 , 0.20)	0.14	-0.33	(-0.73 , 0.07)	0.10
Female						
Unemployment (%)	1.28	(0.97 , 1.58)	<0.001	1.52	(1.16 , 1.88)	<0.001
GDP per capita (1000 USD)	0.24	(-0.03 , 0.51)	0.08	-0.21	(-0.42 , 0.00)	0.045
GDP growth (%)	0.42	(0.10 , 0.24)	-0.12	0.05	(-0.08 , 0.18)	0.42
FLFPR (%)	0.18	(0.18 , 0.22)	-0.22	-0.16	(-0.40 , 0.08)	0.18
Male-to-female ratio						
Unemployment (%)	0.08	(0.04 , 0.11)	<0.001	0.04	(0.00 , 0.08)	0.026
GDP per capita (1000 USD)	0.05	(0.04 , 0.07)	<0.001	0.04	(0.02 , 0.07)	<.001
GDP growth (%)	-0.01	(-0.02 , 0.01)	0.38	0.00	(-0.01 , 0.02)	0.58
FLFPR (%)	-0.02	(-0.05 , 0.01)	0.19	-0.01	(-0.03 , 0.01)	0.39

Note: CI: confidence interval; GDP: gross domestic product; USD: United States dollar; FLFPR: female labour force participation rate; Suicide rates in 1971-2012 were calculated using data including undetermined death, accidental pesticide poisoning, and accidental suffocation.